THE SOLUTION OF THE PILTDOWN PROBLEM

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THE SOLUTION OF THE PILTDOWN PROBLEM

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NOTE.—The curator of a palaeontological collection, which may contain rare specimens of great scientific importance, is frequently faced with the problem of whether to allow such specimens to be reinvestigated by treatment with acids, sectioning, removal of fragments for chemical analysis, or other methods which might seem to involve damage to a unique object. The cautious attitude of a previous generation has undoubtedly preserved for their successors many fossils which, for example, might have been damaged by mechanical treatment in the past, but can now be developed in perfection by more recently devised chemical methods. In the case of the Piltdown relics, one can be certain that after they came into the late Sir Arthur Smith Woodward's possession they would not have been treated or tampered with either chemically or physically. The decision to submit these specimens to a rigorous re-examination was made some years ago ; the final result, unexpected at the time, will be found in the following pages.

W. N. EDWARDS, *Keeper of Geology.*

SINCE the report, some forty years ago,[1] of the discovery of several cranial fragments, a portion of a mandible and a canine tooth at Piltdown in Sussex, the problem of the " Piltdown skull " has been the subject of continuous controversy. Some authorities have accepted all the remains as those of an extinct type of hominid. But it is probably true to say that most anthropologists have remained sceptical or frankly puzzled by the contradictions which they present, for (apart altogether from other details) the combination of a cranium closely similar to that of *Homo sapiens* with a mandible and canine tooth of simian form seemed too incongruous. It has been suggested, indeed, that they really represent the fortuitous association of a Pleistocene human cranium with the remains of a fossil ape which had perhaps been secondarily derived from an earlier geological deposit. The application of the fluorine test (Oakley & Hoskins, 1950), however, made it quite clear that the mandible and canine were certainly not older than the cranium and, *on the assumption that they were all genuine fossils*, it naturally appeared to lend some support to those who held them to be contemporaneous and to belong to the same individual. It is also a fact that the remarkably flat wear of the molar teeth in the mandibular fragment is quite unlike that normally found in apes at a corresponding stage of dental attrition (though similar to the type of wear characteristic of the hominid dentition), while the mode of wear of the large canine tooth is also different from that which occurs in apes. But there is another possible explanation of the apparent contradictions shown by the Piltdown remains : that the mandible and canine tooth are actually those of a modern ape (chimpanzee or orang) which have been deliberately faked to simulate fossil specimens. It was not till one of us (J. S. W.) in the course of personal discussions put forward this proposition fairly and squarely as the only possible solution of the Piltdown puzzle, pointed out that the organic content of the mandible had never been examined, and moreover demonstrated experimentally that artificial abrasion of the teeth of a chimpanzee combined with appropriate staining produced an appearance astonishingly similar to the Piltdown

[1] Dawson & Woodward, 1913.

molars and canine, that we decided on a critical re-study of all the Piltdown material with this specific possibility directly in view. The results of our investigations have now demonstrated quite clearly that the mandible and canine are indeed deliberate fakes. The evidence[1] for this conclusion is briefly as follows:

EVIDENCE OF THE ARTIFICIAL ABRASION OF THE PILTDOWN TEETH

Molar Teeth of the Mandible

(1) The occlusal surfaces (particularly of M_2) are planed down over almost their whole extent to a flatness which is much more even than that normally produced by natural wear (Pl. 9, fig. 2).

(2) The borders of the flat occlusal surfaces—particularly the lateral borders—are sharp-cut and show no evidence of the bevelling which is usually produced by natural wear (Pl. 9, fig. 1).

(3) The centre of the talonid basin in M_2 is unworn, and is bounded by a sharp-cut and unbevelled border of the planed surface of the crown. This appearance would be produced by artificial abrasion but would not be expected in natural wear (Pl. 9, fig. 1).

(4) The surface of the areas of dentine exposed on the antero-medial cusps of the two molars is quite flat and flush with the surrounding enamel, instead of forming a depression as would be expected in natural wear.

(5) In both molars much more dentine has been exposed on the antero-internal than the antero-external cusps. But in the course of natural attrition the lateral cusps of lower molar teeth are normally worn down more rapidly (and thus usually show a greater exposure of dentine) than the medial cusps (Pl. 9, fig. 1).

(6) The degree of wear in the two molars, M_1 and M_2, is almost identical. But in early stages of natural attrition M_1 is commonly (though not always) more severely worn than M_2 (Pl. 9, fig. 3).

(7) The planes of the flat occlusal surfaces of the two molars are not congruous, i.e., they do not fit together to form a uniform contour. Unless the teeth have been displaced from their natural position after death (for which there is no evidence), this incongruity is difficult to explain by natural wear (Pl. 8; 9, fig. 3).

(8) Inspection of the isolated molar tooth (referred to the specimen called Piltdown II) with a binocular microscope shows that the occlusal surface of the enamel has been finely scratched, as though by an abrasive.

Canine Tooth

(1) The mode of wear of this tooth is unlike that found normally either in ape or human canines, for the abraded surface has exposed the dentine over the entire lingual surface from medial to distal border and at one point actually reaches the apex of the pulp cavity (Pl. 9, fig. 5).

(2) The condition of the apex of the root, and the wide and open pulp cavity seen in an X-ray photograph, indicate fairly certainly that the canine was still incompletely erupted or had only just recently completed its eruption. But this would be incompatible with the severe attrition of the crown if the latter were naturally produced (Pl. 9, fig. 4).

[1] The full evidence will be discussed in detail in a later number of this Bulletin.

(3) X-ray examination shows no evidence of the deposition of secondary dentine (with a constriction of the pulp cavity) which might be expected if the severe abrasion of the lingual surface of the crown were the result of natural attrition (Pl. 9, fig. 4).

(4) The abraded surface of the crown shows fine vertically disposed scratches (as seen under a binocular microscope) which suggest the application of an abrasive (Pl. 9, fig. 5).

EVIDENCE OF THE FLUORINE CONTENT

The fluorine method as applied in 1949 (and reported in full in 1950) served well enough to establish that neither the Piltdown cranium nor the mandible was Lower Pleistocene. It did not distinguish (nor at that time was it intended to distinguish) Upper Pleistocene from later material. The rate of fluorination at this site has probably not been high enough to give a clear separation between Upper Pleistocene and, say, Early Post-glacial bones. Moreover the method of analysis used in 1949 was accurate only within rather wide limits when applied to samples weighing less than 10 milligrams, with the consequence that even the difference between the fluorine contents of fossil and modern specimens was obscured where the samples were of that order of magnitude. Improvements in technique have since led to greater accuracy in estimating small amounts of fluorine, and it therefore seemed worth while submitting further samples of the critical Piltdown specimens for analysis in the Government Laboratory. The new estimations, based mainly on larger samples, were made by Mr. C. F. M. Fryd. The following summary of the results leaves no doubt that, whereas the Piltdown cranium may well be Upper Pleistocene as claimed in 1950, the mandible, canine tooth and isolated molar are quite modern.

	$\%F$	$\frac{\%F}{\%P_2O_5} \times 100$
Minimum F-content of local U. Pleistocene bones	0·1	0·4
Ditto. Upper Pleistocene teeth[1]	0·1	0·4
Piltdown cranium I	0·1	0·8
Piltdown cranium II: frontal	0·1	0·8
Piltdown cranium II: occipital	0·03	0·2
Piltdown mandible (bone)	<0·03	<0·2
Molar of Piltdown mandible	<0·04	<0·2
Piltdown canine	<0·03	<0·2
Isolated molar (Piltdown II)	<0·01	<0·1
Molar of Recent chimpanzee	<0·06	<0·3

[1] All the tooth samples were *dentine*.

EVIDENCE OF THE ORGANIC CONTENT

To regard the organic content of bones and teeth as a measure of their antiquity has long been regarded as fallacious, and for that reason no serious attempt has ever been made to test the relative ages of the various Piltdown specimens by that means. However, extensive chemical studies of bones from early occupation sites in North America by Cook & Heizer (1947) have shown that in bones preserved under broadly the same conditions the nitrogen of their protein (ossein) is lost at a relatively slow, and on an average almost uniformly declining, rate. Thus, N-analysis, used with discretion, can be an important supplement to F-analysis, and also for the relative dating of specimens too recent to be within the range of the fluorine method.

Dr. J. D. H. Wiseman and Mrs. A. Foster in the Department of Minerals of the British Museum have devised a method of estimating very small quantities of nitrogen, and Mrs. Foster, using this new method, determined the nitrogen content of a series of samples of the Piltdown material and of selected controls. The following is a summary of the results of this work which agree with all the other evidence indicating that the Piltdown mandible, canine and isolated molar (II) are modern. (The possibility that the Piltdown specimens were steeped in a gelatinous preservative has been borne in mind; if this had been the explanation of their nitrogen-content, the cranial bones which are porous would have shown *more* nitrogen than the highly compact dentine of the teeth; whereas the reverse is true.)

Nitrogen-content of Bone Samples

	%N
Fresh bone	4·1
Piltdown mandible	3·9
Neolithic bone (Kent)	1·9
Piltdown I cranial bones (*average*)	1·4
Piltdown II frontal	1·1
Piltdown II occipital	0·6
U. Pleistocene bone (London)	0·7

Nitrogen-content of Dentine Samples

	%N
Chimpanzee molar	3·2
Piltdown canine	5·1
Piltdown I molar	4·3
Piltdown II molar	4·2
U. Pleistocene equine molar (Piltdown)	1·2
U. Pleistocene human molar (Surrey)	0·3

EVIDENCE OF THE COLOURING OF THE PILTDOWN SPECIMENS

A black coating—ferruginous according to Dawson & Woodward (1914: 87)—covers most of the surface of the Piltdown canine. When this tooth and the molars were sampled in 1948, one of us (K. P. O.) noted that " below an extremely thin ferruginous surface stain the dentine was pure white, apparently no more altered than the dentine of Recent teeth from the soil." Examination by Dr. G. F. Claringbull in the Department of Minerals has now shown that the coating on the canine is in fact non-metallic, it is a tough, flexible paint-like substance, insoluble in the common organic solvents, and with only a small ash-content. The extreme whiteness of the dentine and the nature of the black skin are thus both consistent with the evidence presented above for the essential modernity of the canine.

The mandible is of a reddish-brown colour which, though rather patchy, matches closely enough that of the cranial fragments to raise no suspicion that all the remains (from the original Piltdown site) might not belong to one skull. The frontal fragment stated to have been found at a second site (Piltdown II) is also of a similar brown colour but differs noticeably from the darker greyish-brown occipital fragment from the same site. That the colour of all these fragments is due to iron oxides has been confirmed by direct analysis in the Government Laboratory.

But whereas the cranial fragments are all deeply stained (up to 8% of iron) throughout their thickness, the iron staining of the mandible is quite superficial. A small surface sample analysed in 1949 contained 7% iron, but, when in the course of our re-examination this bone was drilled more deeply, the sample obtained was lighter in colour and contained only 2–3% of iron. The difference in iron staining is thus also in keeping with the other evidence that the jaw and the cranium are not naturally associated.

Smith Woodward recorded (1948: 59; see also 1935: 134) that "the colour of the pieces which were first discovered was altered a little by Mr. Dawson when he dipped them in a solution of bichromate of potash in the mistaken idea that this would harden them." Direct chemical analysis carried out by Drs. M. H. Hey and A. A. Moss in the Department of Minerals at the British Museum (Natural History), as well as the X-ray spectrographic method of Mr. E. T. Hall in the Clarendon Laboratory, Oxford University, confirmed that all the cranial fragments seen by Smith Woodward in the spring of 1912 (before he commenced systematic excavations) do contain chromate; on the other hand, there is no chromate in the cranial fragments subsequently collected that summer—either in the right parietal, or in the small occipital fragment found *in situ* by Smith Woodward himself. This being so, it is not to be expected that the mandible (which was excavated later and in the presence of Smith Woodward, 1948: 11) would be chromate stained. In fact, as shown by direct chemical analysis carried out in the Department of Minerals of the British Museum, the jaw does contain chromate. It is clear from Smith Woodward's statement about the staining of the cranial fragments of Piltdown I (which we have verified), that a chromate staining of the jaw could hardly have been carried out without his knowledge *after* excavation. The iron and chromate staining of the Piltdown jaw seems to us to be explicable only as a necessary part of the deliberate matching of the jaw of a modern ape with the mineralized cranial fragments.

This grave interpretation, which we have found difficult to avoid, receives support from the finding that the frontal and occipital fragments labelled Piltdown II (and found three years later) contain small amounts of chromate. The piece of frontal bone, anatomically, could form part of the cranium of Piltdown I, and in colour and in its content of nitrogen and flourine it resembles the first occipital of Piltdown I rather than that of Piltdown II. Just as the isolated molar almost certainly comes from the Piltdown mandible, it seems only too likely that this frontal fragment originally belonged to the cranium of Piltdown I.

From the evidence which we have obtained, it is now clear that the distinguished palaeontologists and archaeologists who took part in the excavations at Piltdown were the victims of a most elaborate and carefully prepared hoax. Let it be said, however, in exoneration of those who have assumed the Piltdown fragments to belong to a single individual, or who, having examined the original specimens, either regarded the mandible and canine as those of a fossil ape or else assumed (tacitly or explicitly) that the problem was not capable of solution on the available evidence, that the faking of the mandible and canine is so extraordinarily skilful, and the perpetration of the hoax appears to have been so entirely unscrupulous and inexplicable, as to find no parallel in the history of palaeontological discovery.

Lastly, it may be pointed out that the elimination of the Piltdown jaw and teeth from any further consideration clarifies very considerably the problem of human

evolution. For it has to be realized that " Piltdown Man " (*Eoanthropus*) was actually a most awkward and perplexing element in the fossil record of the Hominidae, being entirely out of conformity both in its strange mixture of morphological characters and its time sequence with all the palaeontological evidence of human evolution available from other parts of the world.

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EXPLANATION OF PLATES

PLATE 8

Fig. 1. The Piltdown mandible. Natural size. (1) Outer view; (2) inner view.
[*Photographs by C. Horton.*]

PLATE 9

Fig. 1. The second molar tooth of the Piltdown mandible viewed from its occlusal aspect. × 4 diam. approx. Note the relatively large area of dentine exposed on the antero-internal cusp, and the sharp margin separating the central depression (talonid basin) of the tooth from the completely flattened cusps. Note also the sharp external margin of the " occlusal " surface, with no bevelling.

Fig. 2. The second molar tooth of the Piltdown mandible, viewed from the medial aspect. × 4 diam. approx. Note the extreme evenness of the flat " occlusal " surface.

Fig. 3. The first and second molar teeth of the Piltdown mandible viewed from behind. × 4 diam. approx. Note that the " occlusal " planes of the two teeth are set at an angle to each other.

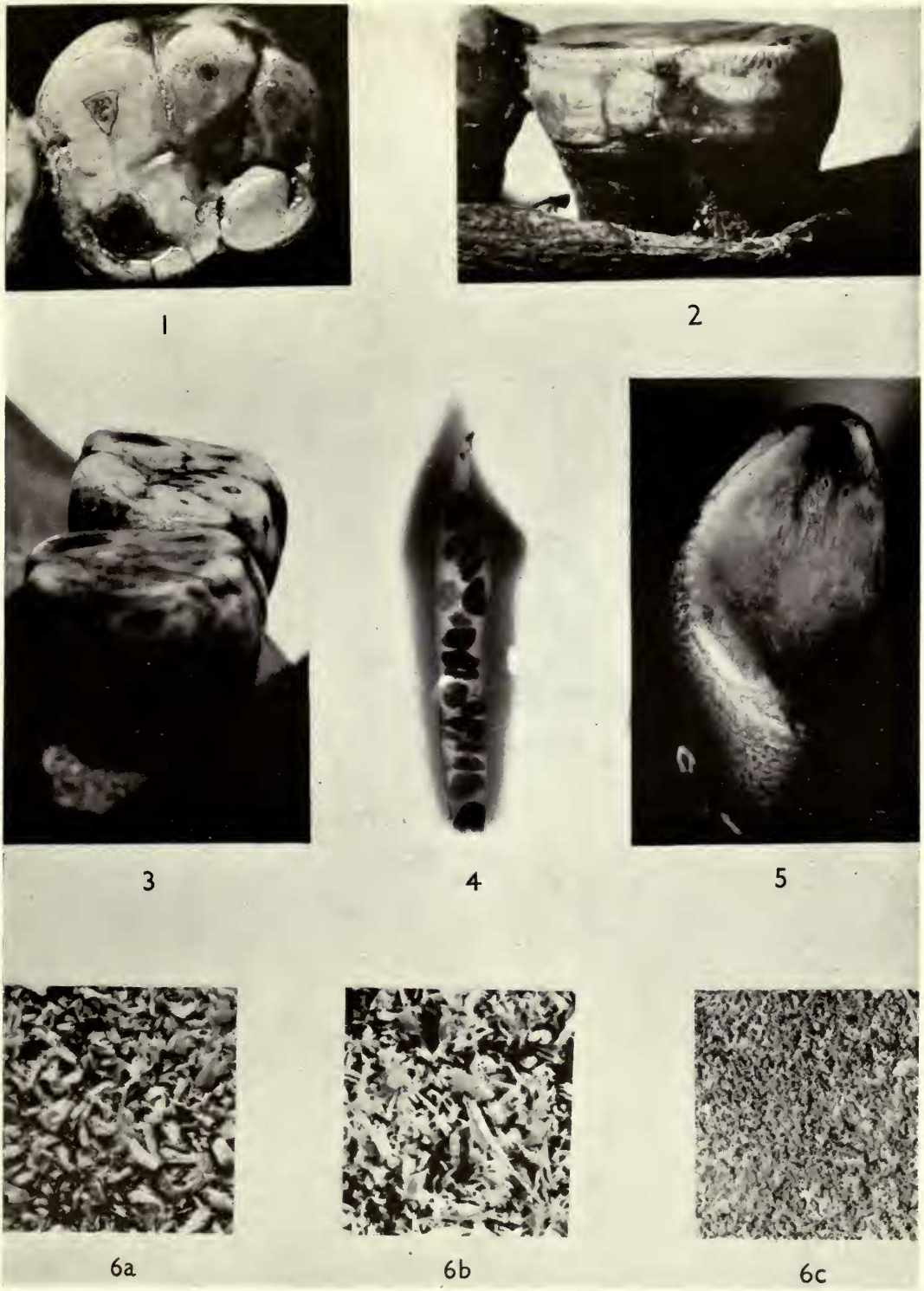
Fig. 4. Radiograph of the Piltdown canine taken in an approximately antero-posterior plane. × 2 diam. approx. Note the thinness of the dentine on the lingual surface towards the apex of the tooth. At one point here the pulp cavity appears to have been exposed and the opening plugged with some material containing radio-opaque particles. The pulp cavity has been packed from the other end with mineral grains.

Fig. 5. The Piltdown canine tooth viewed from the lingual aspect. × 4 diam. approx. Note the fine scratches disposed mainly in a vertical direction. A little above the middle of the surface, towards the apex of the tooth, is seen a small oval area of lighter shade, marking the point where the pulp cavity has been opened by abrasion.

Fig. 6*a–c*. Samples of bone, drilled by L. E. Parsons using a parallel burr size 6, from: (*a*) Piltdown mandible; (*b*) mandible of Recent chimpanzee; (*c*) Piltdown skull (right parietal). × 15. Note that *a* and *b* consist of minute shavings, whereas *c* is a powder.

[*Photographs: C. Horton; X-ray of Fig. 4 by P. E. Purves.*]

THE PILTDOWN MANDIBLE.



PILTDOWN TEETH AND BONE.